

or position, with no single imaging modality encompassing all potential GTV regions. These data suggest delineation based upon multimodality imaging has the potential to improve the accuracy of GTV definition, which is important for highly volumetric approaches to target volume delineation and dose escalation strategies.

#### OC-0064

##### Hypercellularity components of glioblastoma identified by high b-value DWI: the potential for target definition

P.P. Pramanik<sup>1</sup>, H.A. Parmar<sup>2</sup>, A.G. Mammoser<sup>3</sup>, L.R. Junck<sup>3</sup>, M.M. Kim<sup>1</sup>, C.I. Tsien<sup>1</sup>, T.S. Lawrence<sup>1</sup>, Y. Cao<sup>4</sup>

<sup>1</sup>University of Michigan, Radiation Oncology, Ann Arbor, USA

<sup>2</sup>University of Michigan, Radiology, Ann Arbor, USA

<sup>3</sup>University of Michigan, Neurology, Ann Arbor, USA

<sup>4</sup>University of Michigan, Radiation Oncology-Radiology-Biomedical Engineering, Ann Arbor, USA

**Purpose/Objective:** Conventional MRI for target definition of glioblastoma (GB) may receive inadequate radiation dose coverage of the nonenhanced (NE) hypercellular (HC) subvolume resulting in reduced therapeutic efficacy. It is a challenge to differentiate NE solid tumor from edema using conventional FLAIR and ADC ( $b \leq 1000$  s/mm<sup>2</sup>) images. This study aimed to develop a technique to identify the HC components of GB by using high b-value diffusion weighted imaging (DWI) and to investigate the relationship of these components with the enhanced subvolumes, 95% prescribed radiation dose volume (95PDV) and progression-free survival (PFS).

**Materials and Methods:** 21 patients (age: 23-76 years) with GB were treated by radiation therapy (RT) after surgical resection or biopsy. RT planning was based upon conventional MRI. During MRI simulation, DWI was acquired in 3 orthogonal directions with b-values of 0, 1000, and 3000 s/mm<sup>2</sup>. Gross tumor volume (GTV-Gd) and FLAIR abnormality volume (FLAIR TV) were defined on post-Gadolinium T1-weighted and T2 FLAIR images pre-RT. High b-value (3000 s/mm<sup>2</sup>) DWI, in which fluid, edema, grey and white matter, to an extent, are suppressed, were used to define the HC volume (HCV) by using a threshold (mean intensity + 2 SD) calculated from a VOI in normal-appearing tissue most contralateral to the tumor (Fig 1). All images, including planning CT (dose distribution) and MRI at recurrence, were registered to post-Gd T1WI pre-RT. Relationships between the HCV, GTV-Gd, FLAIR TV, 95PDV and PFS were analyzed.

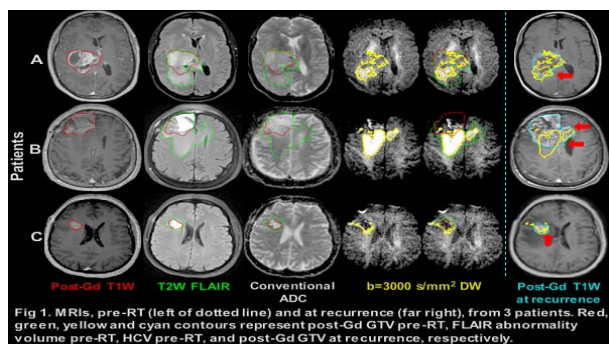


Fig 1. MRIs, pre-RT (left of dotted line) and at recurrence (far right), from 3 patients. Red, green, yellow and cyan contours represent post-Gd GTV pre-RT, FLAIR abnormality volume pre-RT, HCV pre-RT, and post-Gd GTV at recurrence, respectively.

**Results:** The HCVs and NE HCVs varied from 0.58 to 67 cc (median: 9.8 cc) and 0.15 to 60 cc (median: 2.5 cc), respectively. 14 patients had incomplete dose coverage of the HCV, of which 6 patients had 1 cc or more HCV missed by the 95PDV (range: 1.01-25.4 cc), indicating insufficient radiation dose coverage of the HCVs when using conventional MRI. In 7 patients, HCVs extended beyond FLAIR TVs an

average of 13 mm (range: 5-27 mm). However, overall, HCVs were only a median 12% of the FLAIR TVs (median volume of 70 cc and range: 23-180 cc), indicating a potential risk of radiation toxicity if FLAIR TV is used to guide high-dose treatment. Of the 15 patients who had progression, 5 patients progressed earlier, within 6 months post-RT, and 10 patients after. Pre-RT HCVs within the recurrent GTVs-Gd were 78% (range: 65-89%) for the earlier progression subgroup and 53% (range: 0-85%) for the later progression subgroup, indicating the consequence of HCV on PFS. In fact, HCV and NE HCV were significant negative prognostic indicators for PFS (univariate cox regression,  $n = 21$ ,  $p < 0.002$  and  $p < 0.01$ , respectively). The volume of HCV that was not covered by the 95PDV was also a significant negative predictor for PFS ( $p < 0.05$ ), substantiating the importance of high dose coverage of the HCV.

**Conclusions:** High b-value DWI identifies the HC components of GB and could aid in RT target volume definition. Future pathological studies will allow us to investigate the role of high b-value DWI in identifying radiation boost volumes and diagnosing progression.

#### OC-0065

##### Electrical tissue property imaging in patients using MRI to improve hyperthermia treatment planning

E. Balidemaj<sup>1</sup>, H.P. Kok<sup>1</sup>, P. De Boer<sup>1</sup>, R.F. Remis<sup>2</sup>, C.A.T. Van den Berg<sup>3</sup>, G.H. Westerveld<sup>1</sup>, A.J. Nederveen<sup>4</sup>, L.J.A. Stalpers<sup>1</sup>, J. Crezee<sup>1</sup>

<sup>1</sup>Academic Medical Center, Radiotherapy, Amsterdam, The Netherlands

<sup>2</sup>TU Delft, Circuits and Systems Group, Delft, The Netherlands

<sup>3</sup>UMC Utrecht, Radiotherapy, Utrecht, The Netherlands

<sup>4</sup>Academic Medical Center, Radiology, Amsterdam, The Netherlands

**Purpose/Objective:** Hyperthermia treatment (HT) aims at tumour heating to approximately 43°C using RF antennas for energy deposition. For accurate Hyperthermia Treatment Planning (HTP), the knowledge of patient-specific electrical tissue conductivity ( $\sigma$ ) values is required. Currently, HTP applies literature values for  $\sigma$ , which show large variations due to variable measuring conditions (e.g. in vivo, ex vivo, temperature) and use of various species. As  $\sigma$  has a strong impact on the Specific Absorption Rate (SAR) and temperature distribution, studies have shown that uncertainties in tissue  $\sigma$  can lead to inaccuracies of 20% in both SAR and temperature predictions for HTP. Therefore, accurate  $\sigma$  values are essential for reliable patient-specific HTP. Moreover, tumor  $\sigma$  is unknown; therefore currently  $\sigma$  values of muscle are applied. Our aim is to acquire patient-specific tissue  $\sigma$  non-invasively using MRI.

**Materials and Methods:** In vivo  $\sigma$  reconstructions were performed using the Electric Property Tomography (EPT) method which reconstructs the tissue  $\sigma$  from the  $B_1^+$  fields, as measurable by standard MRI systems. We have validated this method earlier using phantom experiments and in vivo simulations in the pelvic region. In the present study, in vivo 3T MRI measurements of 12 cervical (squamous cell) carcinoma patients and one uterine adenocarcinoma patient were used to reconstruct  $\sigma$  values in tumor, muscle and bladder. For a reliable  $\sigma$  reconstruction using EPT, the size of a particular tissue type should be relatively homogenous and large enough (>3cm), therefore, the  $\sigma$  of 9 tumors and 7 bladder fillings could be reliably reconstructed. Results were compared to literature data.